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Radiological Assessment of Target Debris in the National Ignition Facility

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RADIOLOGICAL ASSESSMENT OF TARGET DEBRIS IN THE NATIONAL IGNITION FACILITY

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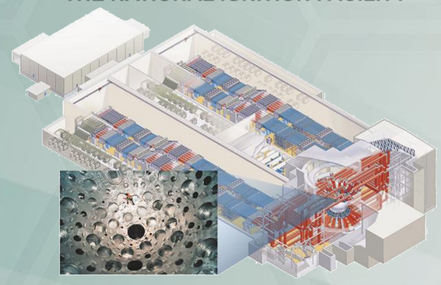
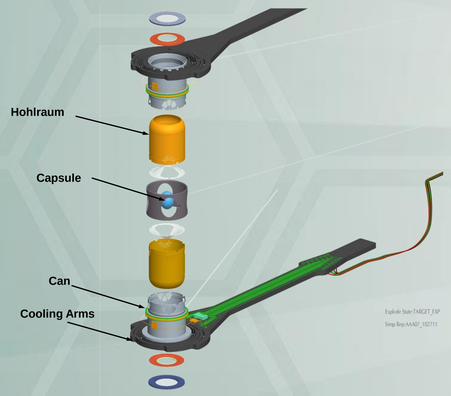
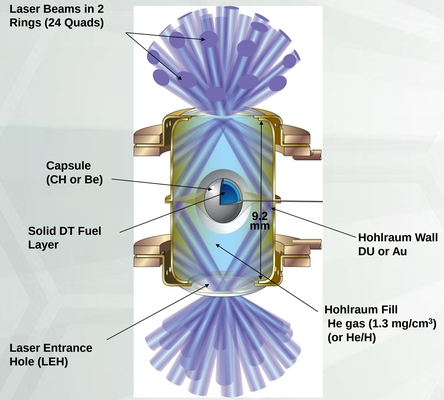
THE NATIONAL IGNITION FACILITY



Construction of the National Ignition Facility at the Lawrence Livermore National Laboratory has been completed with experiments leading to controlled, self-sustaining nuclear fusion and energy gain beginning in 2010

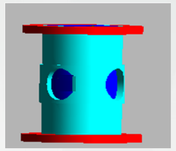
NIC Ignition Point Design





Activation of Hohlraum Materials

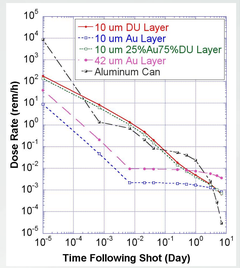
- 20 MJ per shot
- 60 shots per year
- Activated target materials are uniformly deposited on the first wall panels
- Potential external dose rates to maintenance crews are evaluated for different types of proposed capsule and hohlraum materials
- DU-generated fission products are assumed to be trapped inside the chamber
- Dose rates due to target materials are compared to dose rates generated by first wall, chamber and the gunite shield



3-D Model of a Hohlraum

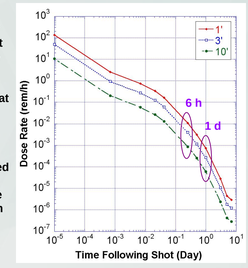
DU Dominates the Short-term Dose

- Activation of the aluminum can (Al-5052) generates equivalent dose to DU during the first few hours
- ^{24}Na generated in activated Al dominates the dose rate during the first 3 days.
- Dose rate due to the 42 μm layer of Au exceeds the DU dose within 12 hours after a 20 MJ shot



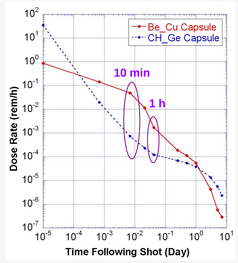
Noble Gases on Cryo-Pumps

- ^{87}Kr, ^{85}Kr and ^{138}Xe are responsible for most of the dose during the first few hours following the shot
- Within a day, dose rate at a distance of 1' drops below 1 mrem/h
- A wait period of about one day is recommended before transporting the noble gases outside the Target Bay for Radchem analysis
- Transporting a small fraction of the gases inventory will allow for faster access



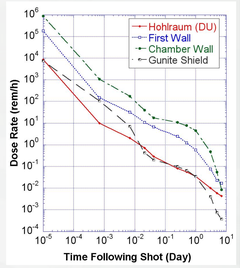
CH Capsule Generates Lower Dose Rates

- Dose rates are calculated at 1' distance from the first wall panels
- Dose rate due to activation of a Be capsule drops to one mrem/h after one hour
- Be capsule dose is dominated by contributions from Cu isotopes, ^{62}Cu and ^{66}Cu
- CH capsule dose rate drops to similar level within 10 minutes
- CH dose is dominated by ^{74}Ga during first hour, and ^{72}Ga and ^{69}Ge during the first day



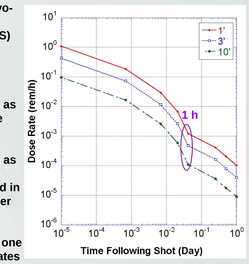
Al Chamber Generates Highest Dose Rates

- ^{24}Na generated in activated Al chamber dominates the dose inside the TC during the first week
- ^{56}Mn and ^{54}Mn generated in activated first wall SS304 are the second and third largest contributors
- Contribution from activated target materials is orders of magnitude lower than the Al chamber



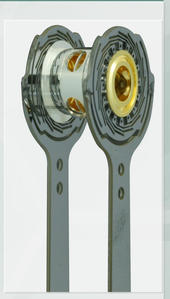
Iodine Capture in Activated Carbon Filter

- Effluent from the TC cryo-pumps to the Tritium Processing System (TPS) will include radioactive iodine
- Smaller molecules containing iodine (such as HI) will be held up in the dryer beds in TPS
- Larger molecules (such as methyl iodide) will pass through and be captured in the activated carbon filter
- Regenerating the cryo-pumps after waiting for one hour will reduce dose rates caused by iodine capture to < 1 mrem/h at 1' distance



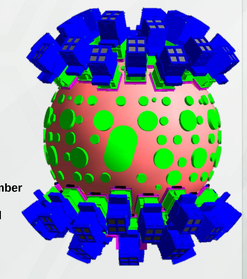
Prototype Ignition Target

- D-T fuel enclosed in a 150 μm-thick capsule
- Two type of capsules are considered:
  - ✓ Copper-doped Be (0.35 at% Cu)
  - ✓ Germanium-doped CH (0.4 at% Ge)
- The hohlraum cylinder is 9 mm high with 5 mm diameter
- Materials considered for hohlraums:
  - ✓ 0.2 mm Au liner
  - ✓ 10 mm layer of DU, Au or DU/Au mixture
  - ✓ 42 mm layer of Au
- 150 μm-thick aluminum can
- Silicon cooling arms



Modeling of NIF Target Chamber

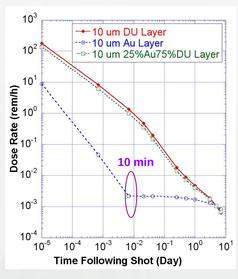
- 192 laser beams
- 1.8 MJ 3 ω light
- 500 TW of power
- 10-m diameter Target Chamber
- SS304 first wall panels
- 10 cm-thick Al-5083 chamber
- 40 cm-thick gunite shield



3-D Model of Target Chamber

Higher Dose Rates are Associated with DU

- Dose rate due to activation of the 10 μm DU hohlraum wall drops to 1 mrem/h after one week
- DU dose is dominated by a large number of fission products
- The Au dose is caused by the decay of ^{197m}Au during the first minute with ^{196}Au responsible for dose beyond the first minute



Activated Noble Gases

- DU-generated fission products are assumed to be trapped inside the chamber
- Noble-gas precursors stay in the Target Chamber and only the noble gases escape to the cryo-pumps
- Evaluation of radiological hazard associated with maintenance activities in the vicinity of the cryo-pumps (containing fission gases) is considered
- Analysis is performed under the assumption that all of noble gas isotopes are not "trapped" in the various crud that collects their precursors
- Results of the this analysis are used to examine the possibility of doping the D-T fuel with Kr and Xe as part of the Radchem diagnostic

Summary

- Activation of the Be-Cu or Ge-doped CH capsules is insignificant
- DU generates higher dose rates than Au during the first day following a 20 MJ shot
- Au produces higher dose rates after longer wait-periods
- Contribution from activated target materials to the overall dose environment inside the Target Chamber is small
- Fission gases generated from the use of DU will significantly decay away within one day after a 20 MJ shot
- A typical wait period of 5 days is planned for all maintenance activities after 20 MJ shots, resulting in a significant reduction in hazards present inside the Target Bay due to the use of proposed target materials

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